of the carbon points, a great portion of which is due to the combustion of the points in the air. M. Lodighin's plan is to employ not two but a single stick of carbon, inclosing it in a hermetically sealed glass chamber from which all air has been exhausted, and an azotic gas which does not combine with carbon at a high temperature, such as nitrogen, let in. When the current from a magneto-electric machine, such as Wilde's, Gramme's, or Noble's, is passed through this carbon it gradually gets heated to a white heat, and emits a brilliant, and at the same time soft and steady light. Fig. 1 shows the form of the carbon used; the light is given off at the narrow central part. The advantages of this plan are that there is a continuous circuit, so that any number of lights may safely be joined up in series to form one or more lamps. The lights can be made as small as desired, the flame is continuous and not injurious to the eye, the cost of new carbon points is saved, and the current can be strengthened or weakened at will very easily. It burns equally well under water, and would be very useful for illuminating dangerous mines, there being no fear of explosion from it. One magneto-electric machine driven by a 3 horse-power engine, generates a light equivalent to many hundred lanterns, and the light can be easily divided up into smaller ones. There was one defect in M. Lodighin's original light which has been remedied by M. Kosloff, of St. Petersburg. The unequal expansion of the metal holder of the carbon and the carbon itself caused the latter to split and give way. The metal also fused, and sparks passed between the carbon and the expanded sockets. Kosloff fixed the carbon on insulating supports of china, clay, crystal, &c., and connected it in circuit by wires. The improved light of Lodighin and Kosloff was first tried in London in 1874, and was very successful. It was awarded the Lomonossow Prize by the Russian Academy of Sciences.

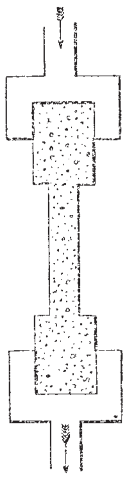


Fig. 1.

But the "electric candle" of M. Jablochkoff has, for the nonce at least, quite cast Lodighin's light into the shade. It appears to be one of those lucky inventions crowning a long series of more or less unsuccessful ones in the same direction. In the electric candle the two carbon points are not dispensed with. They are placed side by side and separated from each other by a slip of an insulating substance such as porcelain, brick, magnesia, but preferably kaolin or pure clay. One of the points is a little longer than the other, and may also be stouter. The positive current is passed down the longer carbon, and leaps across the air space to the shorter carbon, forming the luminous arc at the point of the candle. Such an arrangement of the points is shown in Fig. 2. It is called

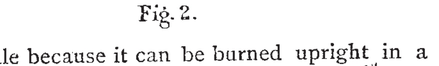


Fig. 2.

a candle because it can be burned upright in a support like a candlestick. The kaolin plays an important part besides insulating the carbons from each other. It becomes incandescent, emitting a beautifully soft, steady, light, and melts away like wax at the same rate as the carbons, just as a candle is consumed with the wick. No mechanism is required for the adjustment of this electric candle. The discovery that kaolin becomes intensely incandescent under the current also enables M. Jablochkoff to dispense with the carbon points for small and medium lights. He made the discovery, we believe, in studying the effect of a succession of sparks from the secondary coil of an induction machine on refractory bodies. He first heated a plate of kaolin to incandescence, but did not fuse it. Then he led the induction current along the edge of the plate by means of a more conductive coating. This caused the edge to fuse and emit a splendid band of light as soft and steady as any known source. This discovery disclosed a feasible system of lighting towns and dwellings by dividing the electric light. It would be possible to generate lights of all sizes by means of the kaolin; and by employing a number of separate secondary coils, one to each candle, for one primary, the current could be simply and effectively divided. By having the carbon candles for large warehouses and public buildings, and a very simple pincher holding a kaolin wick for offices and corridors; and by having separate secondary circuits to each set of lights, electricity could be laid on for illuminating purposes as easily as gas. The passage of the current through the kaolin makes the circuit complete as in Lodighin's plan, and a number of lights can be joined up in the same circuit, so as to form a set of luminous centres. As many as eight candles have been kept steadily burning in the circuit of an ordinary magneto-electric machine. Some of the principal halls of the Louvre have have been lighted by the candle in this way. MM. Denayrouze and Jablochkoff have, we are told, easily obtained fifty luminous centres of various intensity in graduated series, the weakest yielding a glow equivalent to one or two gas burners, the strongest equal to fifteen burners, from one current. By employing a magneto-electric machine giving alternating currents the current interrupter and condenser of the induction coil may be dispensed with, the alternating currents being simply passed through the primary coil. Again, by employing a magneto-electric machine yielding several powerful intermittent currents, the induction coil with its several secondary coils may be dispensed with altogether and the magneto-electric currents passed through the candles. This power of being able to divide up the current so as to have several circuits with several candles of various degrees of illuminating effect in the same circuit, or only one, gives to electric lighting the convenience of gas. It cannot be so expensive as gas, and it must be far less pernicious and dangerous than gas in a house. The lights require to be shaded by ground or opal glass shades to diffuse the rays. The consumption of kaolin is very small. It is said that a piece the length of a centimetre will last ten hours.

The recent public trials of Jablochkoff's light at the West India Docks have been recorded in NATURE. The first was unsuccessful owing to some defect in the magneto-electric apparatus. An account of the second and successful trial was given in NATURE, vol. xvi. p. 152. A large tent inclosing 900 square feet was illuminated by four candles fixed on lamp-posts and surrounded by globes of opal glass. At twenty or thirty feet from the lamps very faint pencil lines could be distinguished on paper, and small print read at a considerable distance. When common candles were substituted for the electric lights the effect was most marked, and the light a sickly yellow. In the electric illumination the most delicate colours retained their purity of tint. A warehouse was also lighted up by three naked candles; and a ship lying alongside a wharf by two, in order to show that lading or unlading could be carried on at night.

J. MUNRO

REDUCTION OF THE HEIGHT OF WAVES BY LATERAL DEFLECTION UNDER LEE OF BREAKWATERS[1]

WHEN a wave encounters an obstacle such as a breakwater, the portion which strikes it is either entirely destroyed or reflected seawards, while the portion which is not so intercepted passes onwards, and spreading

[1] By Thomas Stevenson, F.R.S.E.

laterally under lee of the barrier, suffers a reduction of its height. In the second edition of my book on Harbours, I expressed regret that no attempt had been made, so far as I was aware, to obtain any numerical value of this reduction of height derived either from theory or experiment, although the extent of shelter which is to be gained by the erection of our great national breakwaters depends entirely upon its amount.

From a few observations taken in the sea under lee of the breakwater in Wick Bay, and from some experiments made in a large brewer's cooling vat, it appeared that after passing round an obstruction *the reduction in the height of waves varied as the square root of the angle of deflection.* The approximate formula given in my book was—

$$x = 1{\cdot}00 - {\cdot}06 \sqrt{a}$$

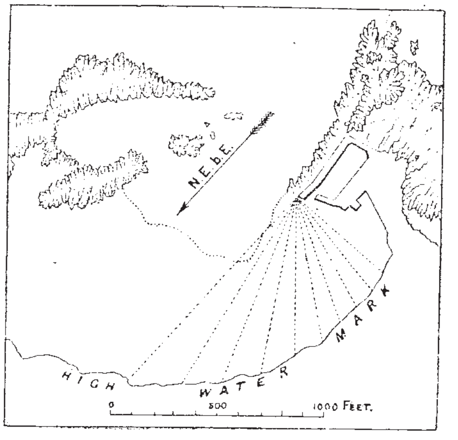
where x represents the ratio of the reduced to the unreduced wave, and a the angle of deflection.

On a recent visit to North Berwick, the finely-curved storm and tide marks traced out on the sandy beach under lee of the promontory at the harbour, reminded me of some observations I had made many years ago at other parts of the Firth of Forth. These observations, which were, however, very imperfect, had for their object the determination of the reduction of the waves by ascertaining the positions in reference to the centre of divergence of different parts of the line of high water mark where, of course, all the wave forces become *nil.* If a beach throughout its whole extent consist of easily moved materials such as sand or gravel, the incursion made at any one place by the sea will obviously depend upon the force of the waves which reach the shore at that place, providing the materials of the beach are homogeneous. In other words, the heavier the waves at any part of the shore the farther inland will the high-water margin retire beyond the tide mark of more sheltered places. And where the waves vary in height owing to some local cause, as, for example, the existence of a sheltering promontory, the high water mark instead of being straight and parallel to the prevalent waves will assume a curved outline.

At North Berwick, the projecting promontory at the harbour, shelters a small bay or rather *bight* from the heaviest waves that fall on that part of the coast. The waves, therefore, are deflected at the pierhead, from which point as a centre, each section of every wave taking its own divergent direction, runs its course till its energy is expended at high water mark. The maximum effect on the beach will consequently be in the line of direction of the undeflected swell, and the minimum effect will be in the direction of the landward end of the promontory where the waves are most deflected from their natural course. Under these conditions, supposing the particles of sand to be of uniform size and of the same specific gravity, the high water margin must assume, as it does at North Berwick, a curved outline owing to the inequality produced by deflection on the height of the waves.

If the distance between the pierhead and the high-water mark measured parallel to the usual direction of the undeflected swell (shown by the arrow in the diagram) be assumed as unity, that distance may be regarded as the measure of the amount of work that the undeflected part of the wave has been able to do, inasmuch as its force has been wholly expended within that distance in driving the beach landwards. The varying lesser distances between the same point and other parts of the high water mark, may in like manner be regarded as representing the work that has been done by the varying lesser forces exerted by the different parts of the wave after being deflected. It is, no doubt, true that the undeflected wave has the full force of the wind to help it, while the deflected has not; but in so far as relates to the engineering aspect of the question, this effect, even though it had been much greater than it is, would be of no importance, as the same conditions hold true with an artificial as with a natural breakwater.

I may mention in corroboration of the views that have been expressed that in the course of my practice as an engineer I have, at different exposed parts of the coast, had occasion to fill up a small creek with soft materials produced by works of excavation at an adjoining part of the shore. In the course of time the whole of these artificial deposits have, in every instance, been removed by the waves, and the former line of high-water been restored. By analogy, therefore, we must believe that if the bay at North Berwick were in like manner filled up artificially with sand as far seawards as the pier-head we should find, after a certain number of storms had occurred, that the whole of the sand had been washed out and the former line of high-water reproduced. If this be true, then the different distances between the pier-head and the high-water mark at North Berwick may justly be regarded as the measures of the varying forces of the



different sections of the deflected wave under lee of the promontory.

The first column in the accompanying table shows the angles of deflection, while the second gives the measurements from the pier-head to the high-water mark as taken from the Ordnance map of North Berwick. The directions in which these measurements were taken are represented by dotted lines on the accompanying woodcut. The third column shows the ratios of those measurements to unity. The fourth column gives the ratios of the heights of the deflected wave calculated by the formula $x = 1 - {\cdot}06 \sqrt{a}$, and the last the *plus* and *minus* differences. Though the employment of the *square-root of the angle* may perhaps be regarded as somewhat unusual, the formula as given is nevertheless more convenient for use than a logarithmic spiral formula, which might give nearly the same results.

Angles of deflection θ.	Distances from centre of deflection to high-water mark v.	Ratios of measurements.	Ratios of Heights of waves calculated by formula.	Differences.
0°	1150	1·00	1·00	·00
10	1000	·87	·81	− ·06
20	920	·80	·73	− ·07
30	840	·73	·67	− ·06
40	735	·64	·62	− ·02
45	700	·61	·60	− ·01
50	675	·59	·58	− ·01
60	600	·52	·53	+ ·01
70	570	·50	·50	·00
80	555	·48	·46	− ·02
90	530	·46	·43	− ·03

Although it is possible that the agreement of the measurements with the results calculated by the formula

may turn out to be to some extent accidental, yet the results can hardly be regarded as very far from correct. And in a case of such importance to the maritime engineer where we have so very few direct observations of the waves in the open sea to guide us, and where it is undeniable that all such observations are invariably found to be excessively difficult to get, and even when got prove often unsatisfactory, any contribution to our knowledge, however imperfect, may be considered of some value; and all the more when, as in this case, the curve traced out on the beach is the result of long-continued action produced by innumerable storms.

A RUSSIAN ACCOUNT OF SCIENTIFIC PROGRESS IN INDIA[1]

WE have already noticed the meteorological journey of M. Wojeikoff round the world. The volume referred to below contains a series of letters written to Baron Osten-Sacken and M. Rykatcheff during his stay in India (December, 1875, to February, 1876).

He had great hopes of the development of meteorology in India. A series of stations working upon one uniform plan, together with a system of weather-warnings, was about to be established throughout the country under the superintendance of Mr. Blanford. That gentleman expected a great deal from a thoroughly organised system of weather-forecasts, owing to the periodicity and comparative regularity of meteorological phenomena in India. The non-periodical fluctuations are yet certainly very large—especially as to rains—but they are less complicated than elsewhere, and it was likely to be easier to detect the laws they obey. Already in 1874 the Government asked Mr. Wilson whether it was probable that the rainy period would be as short that year as it was in 1873; Mr. Wilson answered that he expected heavy rains at the end of the monsoons, and October was in fact very rainy. The importance of such forecasts may be seen at a glance, as the rice-crops depend entirely upon the quantity of rains and the time when they finish, the rice-fields giving the best crops when they remain under water during the first two months after the sowing.

A subject treated at greater length by M. Wojeikoff is the Black Earth of India. This fertile soil appears mostly in the western and southern parts of the country, especially on the table-land of the Deccan, whilst on the plains of Bengal and in the north-western provinces it is, on the contrary, nearly wanting. It attains its largest development on traps, being found only as smaller patches on the bottoms of valleys in the districts of crystalline rocks. Altogether, it does not occupy in India such extensive uninterrupted spaces as in Southern Russia, and even in the provinces where it is most developed, it covers but from fifty to seventy per cent. of the surface of the land. The data as to its thickness are few; six feet is not unusual, but thicknesses of twenty feet must have been observed on some deposits washed down from the slopes of the hills. A few analyses show a percentage of from 7·7 to 9·2 of organic matters, not much different from what was found in the black earth of Russia.

As to its origin, the most curious opinions continue to prevail among Indian geologists. Some suppose it to be merely a product of the disaggregation of traps; others continue to support the old opinion as to its origin in marshes. Dr. Oldham, who was the first to renounce an erroneous view long established in Western Europe, in a letter to M. Wojeikoff, adopted the theory of the origin of black earth from "a dense vegetable growth, principally herbaceous, but partly arborescent," although there are localities where it may have come "from jheels and marshes." M. Wojeikoff supports the opinion now prevailing in Russia, that Black Earth is the result of a herbaceous steppe-vegetation accumulated during long centuries. He points out that its marshy origin is contradicted by the facts that, 1, the percentage of organic matter in its upper and lower parts is much the same, while in marshy deposits it constantly decreases in the upper parts; and 2, Black Earth never contains a large amount of acids, as is always the case in marshy deposits. Therefore, Black Earth mostly covers the surface of the lower table-lands, and is of far rarer occurrence in the bottoms of valleys. As to these latter deposits many misconceptions still prevail. Many of them are secondary, being washed down by rains from the tops and slopes of hills, and M. Wojeikoff supposes that the black-earth in the lower parts of the Nerbudda, Taptee, Godavery, Kistna valleys, &c., has mostly such a secondary origin. There are many instances when the black-earth of low levels is not a secondary deposit. It is then the product of a grassy meadow-vegetation, grown upon the former marshy deposit *after* the total draining up of the marsh.

We notice, also, his remarks upon the interest afforded by India for ethnographical and anthropological explorations. There is much to do in these departments. An official report says that not less than two-thirds of the old monuments of India remain unexplored; and there are large parts of the country, as, for instance, the Central Provinces, where almost nothing was done in this direction. The question as to the origin of some of the aborigines of India is still very obscure. The origin of the Dravidians, for instance, seems to be very uncertain, and M. Wojeikoff had much trouble to procure for Dr. Hochstetter some twenty photographs of this interesting people. He warmly recommends India as a field for anthropologists.

[1] *Isvestia* of the Russ. Geogr. Soc., 1876, No. 3.

METEOROLOGY AND THE INDIAN FAMINE

THE following letter appeared in the *Times* of Saturday last:—

In a recent article on the Indian Famine you asked whether science could do nothing to foresee and provide for these appalling calamities. I think that, as regards Madras at any rate, science may safely accept your challenge. The present famine was foreseen on meteorological grounds last year, and the continued drought during the present summer (an unusual feature in Indian famines) was indicated in a printed research as early as February. Meteorologists have for some time been aware that the eleven years' cycle of sun-spots is coincident with a cycle of atmospheric conditions producing ascertained terrestrial effects. Thus the minimum periods of sun-spot activity are coincident with the minimum appearances of the aurora and with the minimum number of cyclones, while the maximum periods of sun-spot activity are contemporaneous with the maximum activity of the aurora and of cyclones. The coincidence between the sun-spot cycles and the variations in the indications of the magnetic needle has also been affirmed, and a periodic connection between solar activity and terrestrial magnetism is now an accepted fact of science. A similar connection between the eleven years' cycle of sun-spots and the temperature and rainfall had also been suspected, and various researches had been undertaken to show that the supposition was well founded. It was at this stage of the inquiry that Dr. W. W. Hunter, the Director-General of Statistics to the Government of India, commenced his investigations last year into the rainfall of Madras. During this century six years of minimum sun-spots had occurred (1810 to 1867); and for practical purposes the present year, 1877, may be taken as the seventh period of minimum sun-spots within this century. Dr. Hunter also found that six great scarcities of sufficient gravity to be officially returned as "famines" had occurred during the same period (1810-77). Of these six famines five were caused by years of drought coincident with, or adjoining to, the periods of minimum sun-